Weather Information Communications (WINCOMM) Overview and Status

Weather Accident Prevention

2nd Annual Project Review

June 5-7, 2001

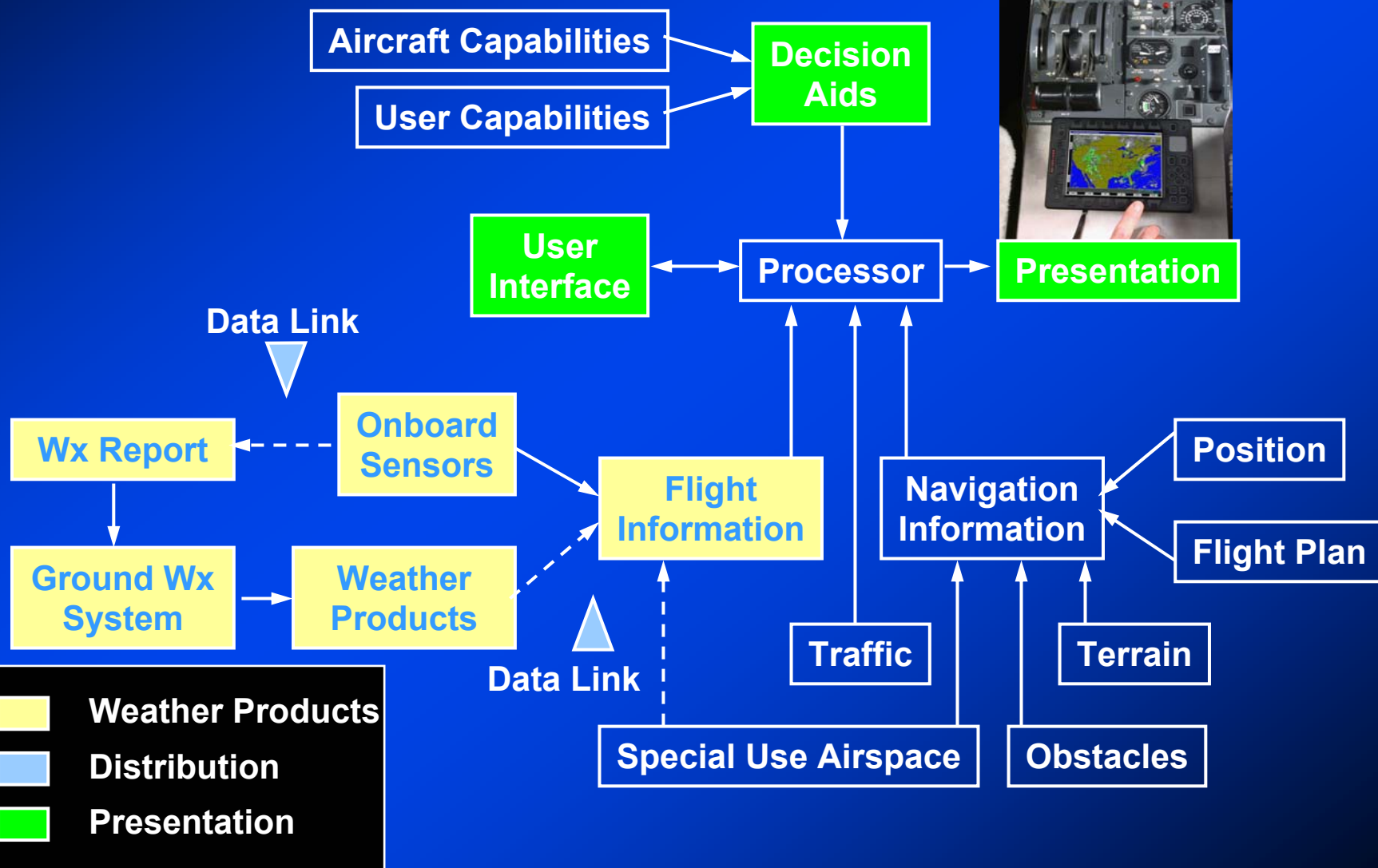*Cleveland, OH*

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In-Flight Weather Information

- Aircraft Capabilities
- User Capabilities
- Decision Aids
- Presentation
- User Interface
- Processor

Data Link

- Wx Report
- Onboard Sensors
- Flight Information
- Navigation Information
- Position
- Ground Wx System
- Weather Products
- Flight Plan
- Traffic
- Terrain

Data Link

- Special Use Airspace
- Obstacles

Legend:
- Weather Products
- Distribution
- Presentation

System Elements

Weather Products → Distribution → Presentation

Enhanced Weather Products **(AWIN)**

Communications Networks and Data Links **(WINCOMM)**

Operator Support **(AWIN)**

Technology Investment Areas

- Datalink Requirements & Architecture Analyses:
  - Mid-Term (2010)
  - Far-Term (>2020)

- Air/Ground Datalinks
  - Ground-based (terrestrial)
  - Satellite-based
  - Airborne-based

- Network Technologies
  - Aeronautical Telecommunications Network (ATN)
  - Internet Protocol (IP)

(Focus: Commercial Air Transport and General Aviation)

NAS Information Exchange

Options:

- Analog Voice
- ACARS
- VDL Modes 2-4
- Mode S
- UAT
- SATCOM
- HFDL
- Commercial
- Proprietary Links

AIRBORNE WEATHER OBSERVATION

VOICE

MESSAGING

NEGOTIATION

OPERATIONS, MAINTENANCE

AIRCRAFT

AIRCRAFT

ADS-B EPIREP

POSITION/ INTENT

FIS TIS APAXS

WEATHER NAS STATUS

- TV, RADIO
- INTERNET

AUTOMET

NEXCOM

CPDLC

DSSDL

ADS-B

AOC COMM

NWIS

OTHER AUTHORIZED USERS

INTERNATIONAL MILITARY FBO'S, FSSs...

NWS & PRIVATE Wx PROV

AIR TRAFFIC MGT

AIRLINES OPERATIONS CENTER

FIS Datalink Architecture Analyses*

Key results to date:

- SAIC, ARINC, TRW, Crown Communications Weather Datalink Architecture Study (May, 2000) and in-house analyses:
  - Broadcast is preferable to addressed 2-way for FIS (Weather)
  - VHF-Broadcast can support regional FIS data, however challenge to meet national implementation goals (coverage/interference)
  - Need broadband solution which could support regional/national goals (SATCOM and/or line-of-sight)
  - Hybrid broadcast solution, optimal:
    - Ground-based narrowband for local/regional FIS
    - SATCOM for national/strategic

Hybrid FIS Datalink Architecture
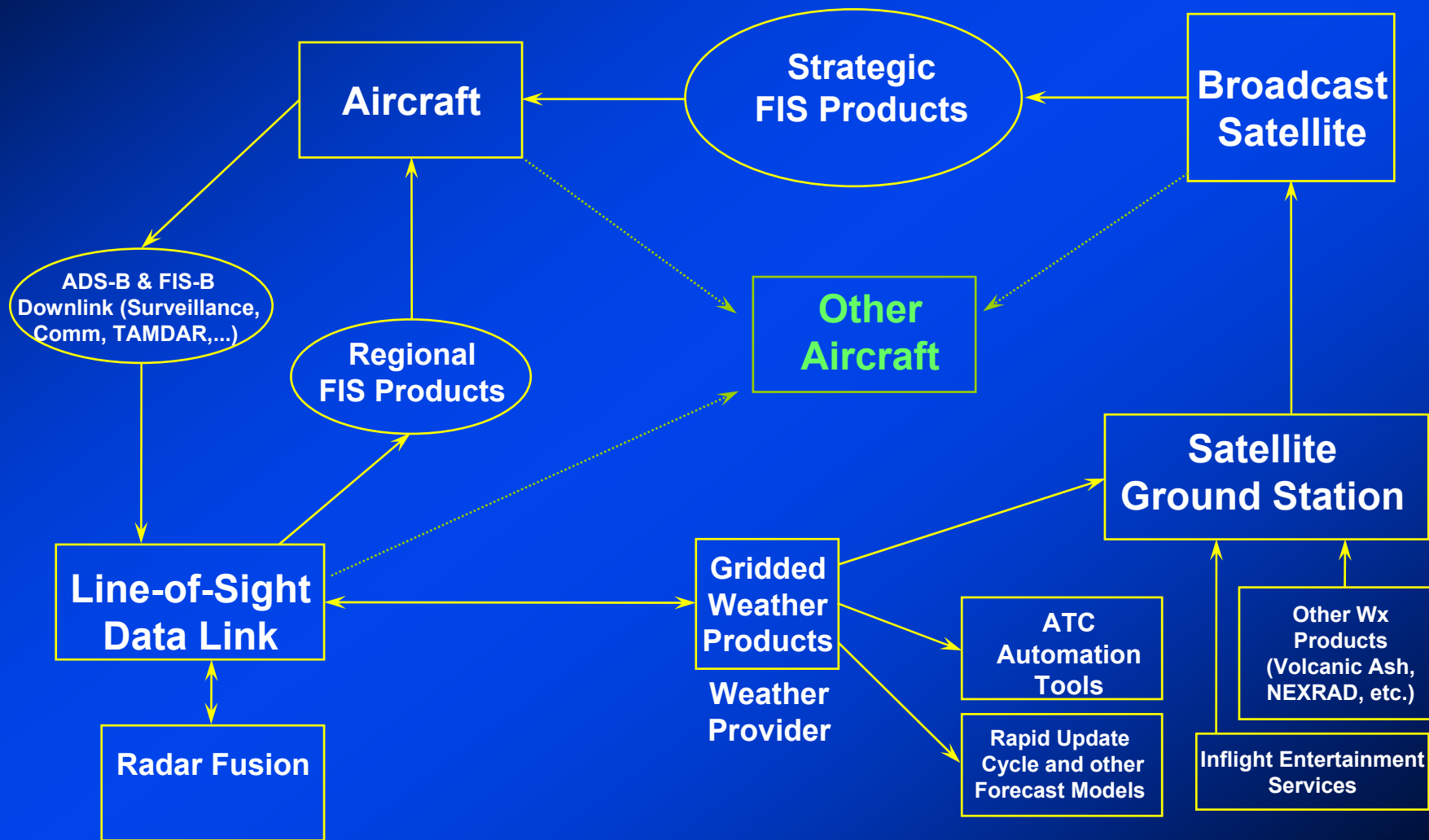
FIS Datalink Architecture Analyses*

On-going tasks:

- Comprehensive AutoMET/TAMDAR datalink architecture options

- JH/APL tasks:
  - Independent investigation of ground, satellite and hybrid datalink architectures for FIS
  - 2007-2015 implementation timeframe
  - Investigation of 'ADS-B' datalinks for FIS/Wx and low-altitude AutoMET (TAMDAR) dissemination
    - Mode S (1090), UAT, VDLM4
    - Supported by high fidelity modeling and simulation
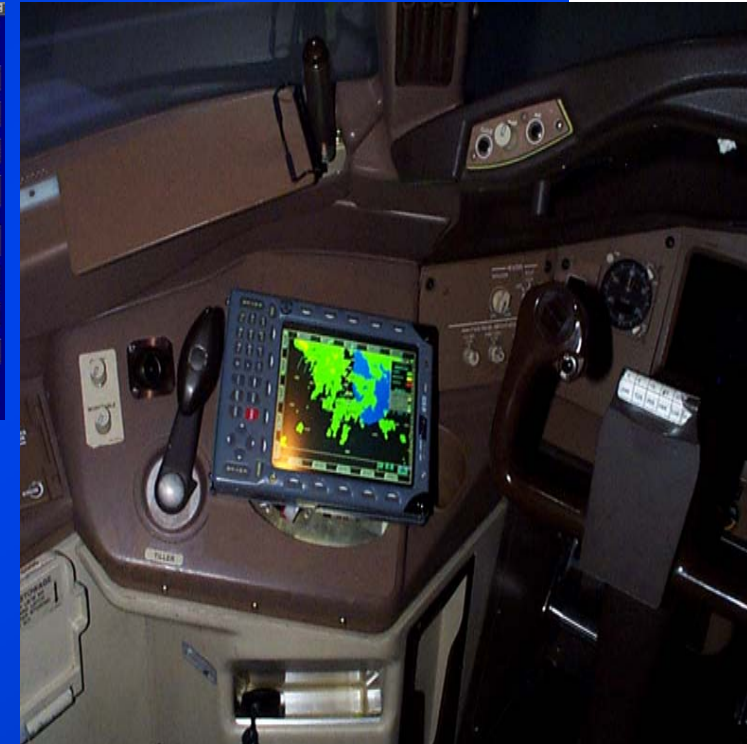
Air Transport: Ground-based Datalinks*

FedEx MD-11

USAF C-135C
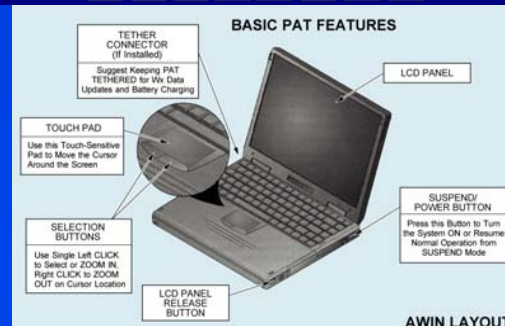
Boeing Transport Cooperative Agreement

Honeywell Transport Cooperative Agreement

- Phase I (FY98-00) efforts (Boeing & Honeywell) utilized off-the-shelf comm for rapid implementation (air phone, VHF/ACARS, …)

- Optimal long-term operational end-solution may differ (VDL Mode 2, SATCOM)

- Recent In-Service-Eval's (ISE) of HI system by UAL (Electronic Flight Bag concept)

Air Transport: Ground-based Datalinks*

Results to date:

• Grants with Ohio University to assess addressed VDL-Mode 2 datalink for weather dissemination.

• Laboratory bench testing completed

• Initial flight experiments completed (Ohio U King Air)

Future activity:

• Partnering with ARINC to jointly evaluate VDL-2 datalink performance for FIS (Weather) applications. (VDL-2 is future upgrade to ACARS)

• Experiments will include both signals-in-space as well as network characterization (ATN).

• Hardware will be integrated on NASA B-757 research aircraft for upcoming flight experiments with ARINC ground-system.

Air Transport: Ground-based Datalinks*

Equipment

Ohio University King Air

Transmitter Location

NASA Langley B757 Aircraft

Air Transport: Satellite-based Datalinks*

Worldwide Transport
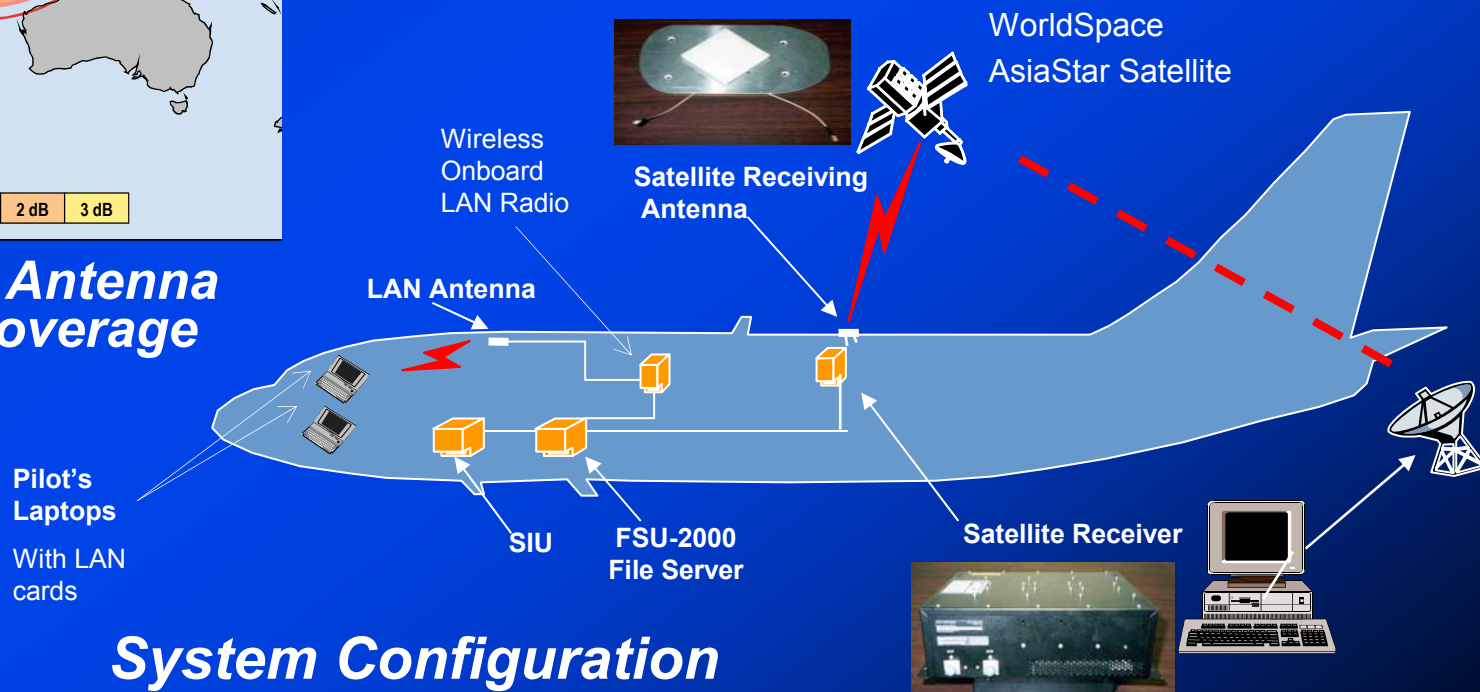
Technology development and operational evaluation of graphical weather to the cockpit via broadcast SATCOM for commercial transport oceanic operations
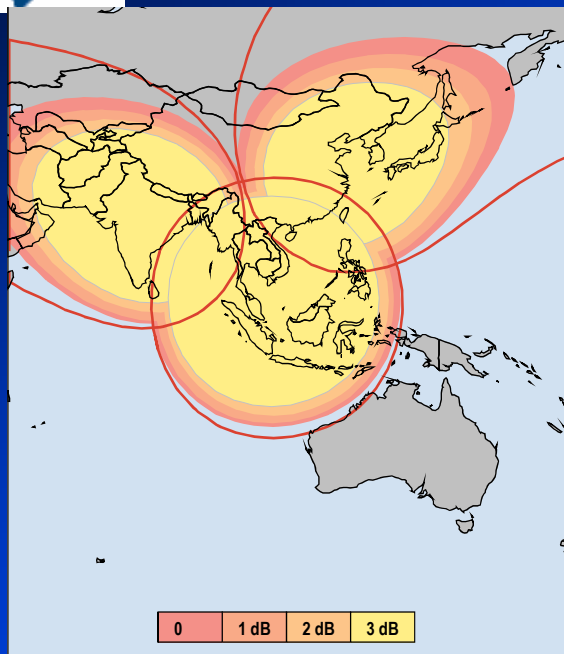
AsiaStar Antenna Beam Coverage

| 0 | 1 dB | 2 dB | 3 dB |

WorldSpace
AsiaStar Satellite

Wireless Onboard LAN Radio

Satellite Receiving Antenna

LAN Antenna

Pilot's Laptops

With LAN cards

SIU

FSU-2000 File Server

Satellite Receiver

System Configuration

Air Transport: Satellite-based Datalinks*

Worldwide SATCOM Transport Datalink:

- NASA / Rockwell Collins / Jeppesen / American Airlines / Worldspace team

- Government/industry cost-sharing

- In-Service Evaluation via two American Airlines B-777s flying trans-pacific routes

- 1st 777 install completed, including all certs

- 2nd 777 install completion May, 2001

- Trial 'runs' completed to Japan

- First 'official' flight May 21, 2001; commence data collection thereafter

Air Transport: Satellite-based Datalinks

- Enabling technologies:
  - Phased array antennas
  - Broadband mobile terminal

- Joint NASA/Boeing development

- Up to 1000x capacity increase
  - 256 Kbps off aircraft
  - 2.18 Mbps to aircraft

- Ground-mobile experiments

- Proof flight test Dec, 2000 (DC-8)

- Upcoming B-757 experiments

- Enabling to *Connexion by Boeing*

GE-2

DC-8

GRC

DFRC

ARC

General Aviation: Ground-based Datalinks*

- Cooperative NASA research with ARNAV and Honeywell (NavRadio)

- VHF-based broadcast & 2-way datalinks
  - VDL-Mode 2
  - GMSK

- Addresses near-term need for broadcast of graphical weather to the G/A cockpit

- Resulting FAA/industry implementation:
  - G/A focused service volume
  - Dual vendors (ARNAV & Honeywell)
  - 5 year FAA contract (FY00-04)
  - 2 national frequencies per vendor
  - Free text weather products
  - Fee-based value/graphical products
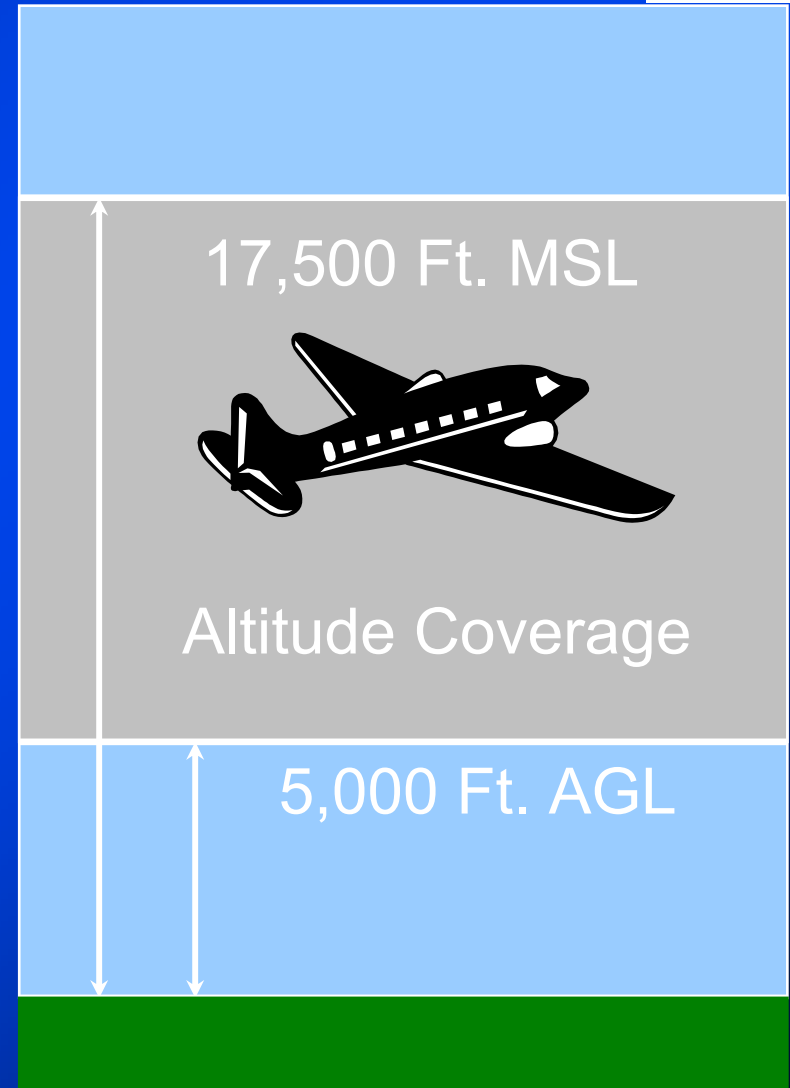
17,500 Ft. MSL

Altitude Coverage

5,000 Ft. AGL

General Aviation: Satellite-based Datalinks

Flight test and evaluation of worldwide weather datalink capability using broadcast Satellite Digital Audio Radio Services (S-DARS).

Johannesburg, South Africa

September, 1999

Internal Equipment (GPS, Laptop Computer, etc.)
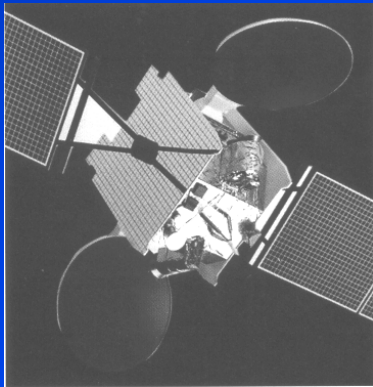
AfriStar Satellite

Patch Antenna Mounted to Cessna 172

Satellite

Receiver

16

General Aviation: Satellite-based Datalinks*

Satellite providing
CONUS coverage

PWA™ airborne
weather display

PWA™
antenna

PWA™ weather data

PWA
receiver

NPWA1

Based on
US Patent
#5265024
Nov. 23, 1993

Monitoring
network

Ground
station

ViGYAN
ground
processor

Weather
data

SBIR Phase III with ViGYAN
• Enable Pilot Weather Advisor™
• Low-cost SATCOM broadcast
datalink
• Initial flight evals Fall, 2001

17
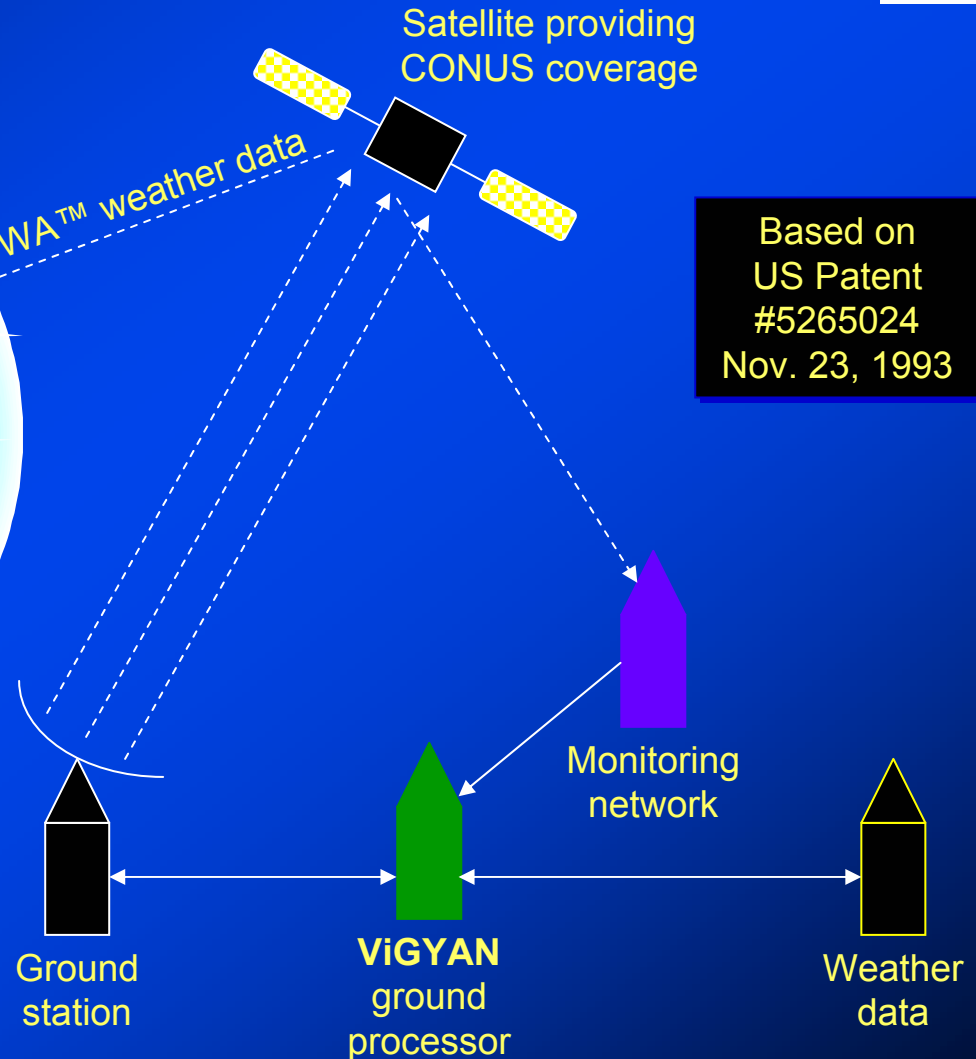
Low-Altitude AutoMET Reporting

- Use aircraft operating below 20,000 ft altitude to sense and report
  - Moisture
  - Temperature
  - Winds

- To be used by:
  - Forecast models
  - Weather briefers
  - Controllers
  - Other aircraft

- Investigating numerous airborne-based datalinks and architectures for technical feasibility

MDCRS & AMDAR Coverage from Transports

20,000 ft. MSL

AutoMET Coverage
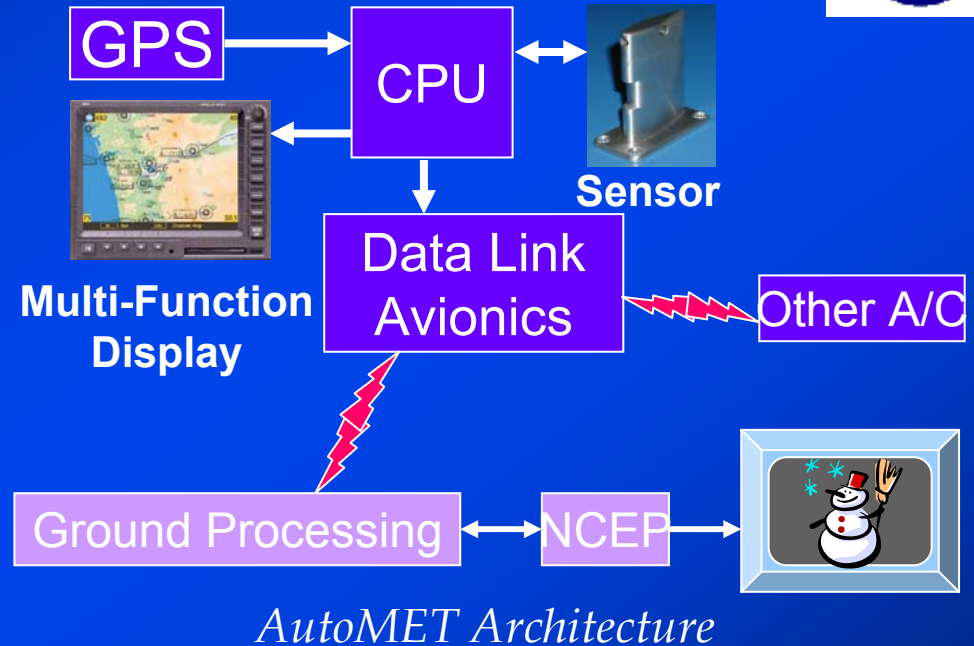
Ground Level

AutoMET: Airborne-based Datalinks*

Airborne-based Datalinks:

- Extension of MDCRS service (ACARS/ARINC)

- VHF/GMSK (ARNAV Systems)

- VDL-Mode 2 (ARINC & HI)

- UAT (FAA Capstone & UPSAT)

- Satellite (OrbComm, others)

- ADS-B Datalinks (JH/APL)

GPS → CPU ↔ Sensor

Multi-Function Display

CPU → Data Link Avionics ↔ Other A/C

Data Link Avionics → Ground Processing ↔ NCEP →

AutoMET Architecture

NASA Cessna 206

Network Protocols Development

- Past tasks with MIT/LL for FIS:

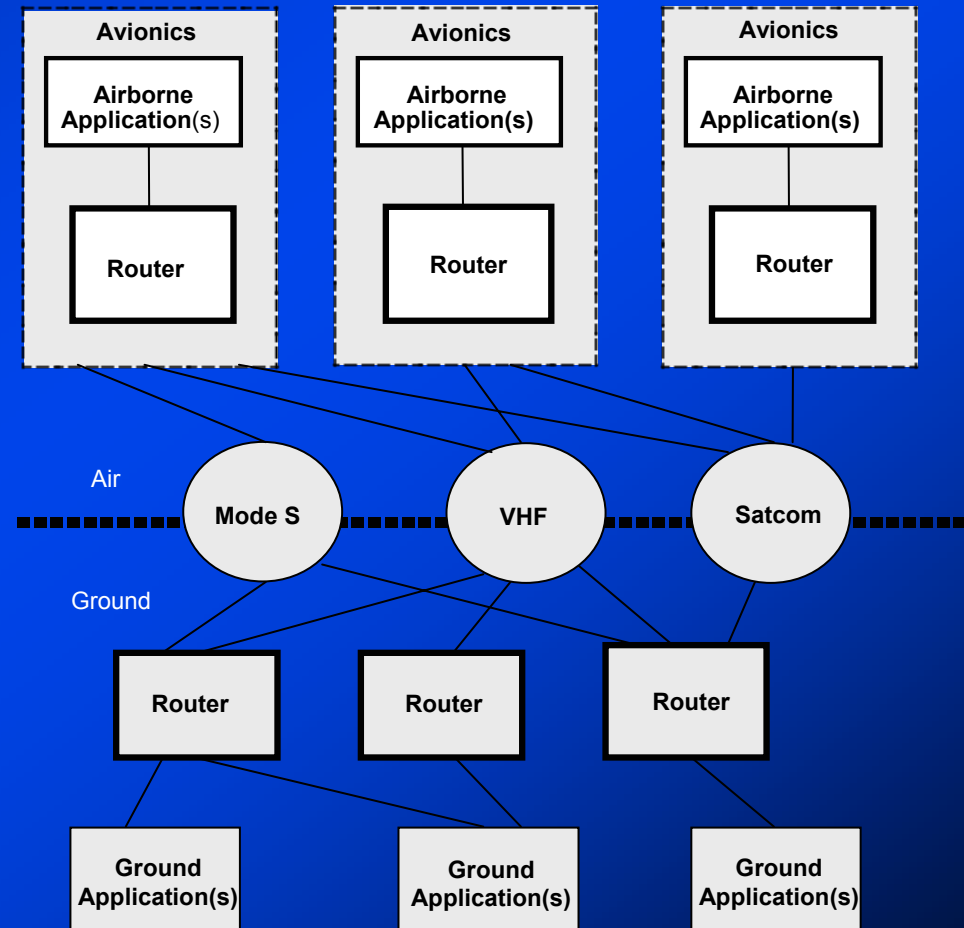 - ATN and Internet Protocol (Mobile IP) network feasibility

  - IP-over-VDL Mode 2 datalink interface definition

- Joint NASA/ARINC research:
  - FIS over IP/VDL-Mode 2
  - FIS over ATN/VDL Mode 2

- ATN over broadband SATCOM feasibility

- Next-generation Mobile IP research for aeronautical app's

Network Routing Connectivity

FAA/NASA Collaboration

- FIS Datalink & Weather Requirements Offices (AUA & ARW)
  - Co-funded tasks under NASA/FAA Memo of Agreement:
  - Low-altitude AutoMET datalink technical architecture alternatives
  - FIS/Weather datalink technical architecture analyses:
    - Mid-Term (2004-2007)
    - Far-Term (2010 and beyond)
  - Terminal area weather datalink communications alternatives

- Office of Architecture and System Engineering (ASD)
  - Joint Research Project Definitions (JRPDs):
  - FIS datalink architecture analyses & NAS Architecture integration
  - Terminal area broadband communications

- CAPSTONE Program (Alaska)
  - UAT datalink investigation for AutoMET; SATCOM augmentation

Summary

- NASA datalink technology investments in
  - FIS datalink architecture development guidelines
  - Ground, satellite and airborne weather datalink systems and supporting network standards

- Strong partnerships with industry, FAA and academia evidenced by
  - Cost-shared NASA/industry technology development
  - Jointly co-funded NASA/FAA tasks

- As a result, beginning to see introduction of 1st generation systems into the marketplace

- Continued future NASA research and technology development into breakthrough, next-generation systems and component technologies.